Two-proton correlation function from Pb+Pb central collisions

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It is known that the baryon density plays an important role in the dynamical evolution of heavy ion collisions. To measure the spatial baryon density, one needs information on the size of the baryon source. The size of the proton source at freeze-out can be inferred from two-proton correlation functions.[1]

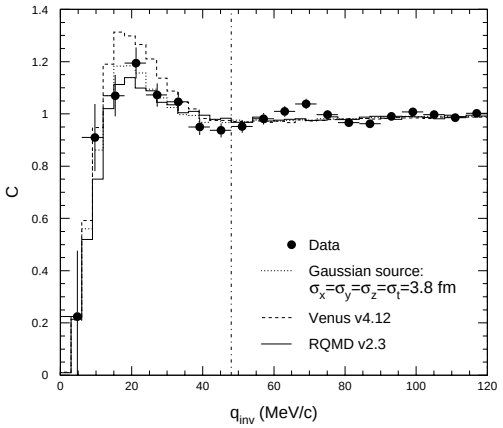

Figure 1: The corrected two-proton correlation function (points, errors shown are statistical only), compared to calculations for a Gaussian source (dotted), and for freeze-out protons from RQMD v2.3 (solid) and VENUS v4.12 (dashed).

NA49 has measured the two-proton correlation function at midrapidity from the most 5% central Pb+Pb collisions at 158 AGeV. Protons in the rapidity range $2.4 < y < 3.4$ ($y_{\rm c.m.} = 2.9$) and transverse momentum $p_T < 2$ GeV/c are used. There are two main sources of contamination: kaons misidentified as protons using the dE/dx technique, and protons from weak decays which are incorrectly reconstructed as primary vertex tracks. The measured two-proton correlation function is corrected for the contamination and the finite momentum resolution, and is plotted in Figure 1. ($q_{\rm inv}$ is the momentum magnitude of either proton in the pair rest frame.)

In order to extract the proton source size at freeze-out, we compare the measured correlation function to theoretical calculations: (I) thermal Gaussian source model, (II) the microscopic transport model RQMD, and (III) VENUS. The calculated two-proton correlation functions are plotted in Figure 1 with the data. We note that RQMD and VENUS models bracket the data.

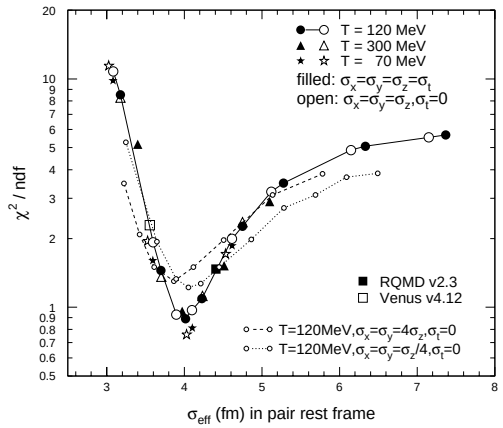

Figure 2: The χ^2/ndf values as function of $\sigma_{\rm eff}$ for various model calculations with respect to the measured correlation function: thermal Gaussian source model (circles, triangles, and stars), RQMD v2.3 (filled sqaure) and VENUS v4.12 (open square).

We quantify the differences between the data and the calculations by χ^2/ndf in the range $q_{\rm inv} < 48$ MeV/c. and the proton source size $\sigma_{\rm eff}$, by $1/\sqrt{2}$ of the geometrical average of the pair distance in one-dimension in the pair rest frame. The χ^2/ndf values are plotted against $\sigma_{\rm eff}$ in Figure 2. All three models studied follow the same curve, underlining the sensitivity of the variable $\sigma_{\rm eff}$ in describing two-proton correlation functions. From the minimum χ^2/ndf point, we extract an effectice size $\sigma_{\rm eff} = 4.0 \pm 0.15$ fm for the proton source at midrapidity in Pb+Pb central collisions.

Footnotes and References

[1] S.E. Koonin, Phys. Lett. 70B (1977) 43; D.H. Boal, C. Gelbke, and B.K. Jennings, Rev. Mod. Phys. 62 (1990) 553; R. Lednicky and V.L. Lyuboshits, Sov. J. Nucl. Phys. 35 (1982) 770; S. Pratt and M.B. Tsang, Phys. Rev. C 36 (1987) 2390.